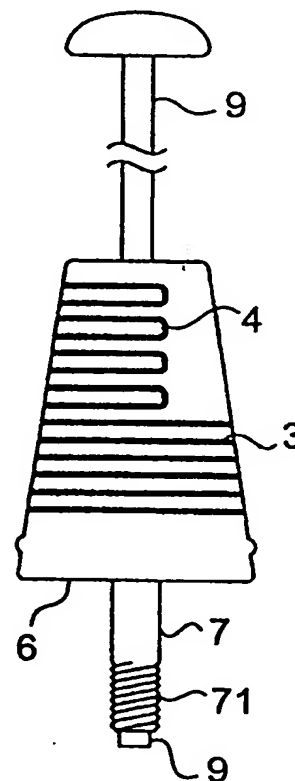




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(54) Title: A MATCHED ANTENNA DEVICE AND A PORTABLE RADIO COMMUNICATION DEVICE INCLUDING A MATCHED ANTENNA DEVICE (57) Abstract A matched antenna device (1) for a radio communication device, comprising a matching means (3, 33) and a first antenna element (4). The matched antenna device (1) comprises a flexible dielectric substrate (2) carrying the matching means (3, 33) on a first side (21). The matching means (3, 33) comprises a conductive pattern (3), having a first coupling means (31) and a second coupling means (32), and exhibits inductive and capacitive characteristics. The flexible substrate (2) is to be attached to the radio communication device so as to capacitively couple the conductive pattern (3) to signal ground of the radio communication device. The first coupling means (21) is to be coupled to the circuitry of the radio communication device, and the second coupling means (32) is coupled to a feed portion (42) of the first antenna element (4).		



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A MATCHED ANTENNA DEVICE AND A PORTABLE RADIO COMMUNICATION
DEVICE INCLUDING A MATCHED ANTENNA DEVICE

FIELD OF THE INVENTION

5

The invention relates to a matched antenna device for a radio communication device, including a matching means and a first antenna element.

10 Further it relates to a radio communication device, including a matched antenna device.

RELATED ART AND BACKGROUND OF THE INVENTION

15 In a radio communication device the transmitting/receiving circuits are coupled to the feed point of a radiator means via a feed line. Normally, the transmitting/receiving circuits have a nominal impedance of $50 + j0$ ohm. If the impedance of the radiator feed point differs substantially from that of the
20 transmitting/receiving circuits, an impedance matching means is required for matching the impedance of the radiator to the impedance of transmitting/receiving circuits.

The radiator and the impedance matching means may then be
25 interconnected by a second feed line or similar having a given length. This feed line is influenced electromagnetically by different conductive or dielectric bodies in its surroundings, for example a support on which the radio device is resting, the hand and head of an operator, or the chassis of the radio
30 device or conductive parts thereof. Especially when the radiator feed point impedance is high, the length of the second feed line is significant to the environmental influence on the antenna performance. The higher the impedance of the

feed point and the longer the second feed line, the higher the sensitivity to environmental variations.

5 A radiator of quarter-wave type may not require an impedance matching means to be connected to 50 ohm circuitry. Sometimes, a quarter-wave radiator is preferred since it allows the antenna means to be relatively short and non-obstructive. However, a drawback of quarter-wave radiators, for example in cellular telephones, is that currents are inevitably generated
10 on the chassis of the telephone. The antenna performance is then sensitive to influence by, for example, the operator holding the telephone or pressing it to his ear.

15 Also, from another point of view, it is desirable to use a radiator with relatively high impedance, for example a half-wave type radiator or similar. Generally, a half-wave type radiator provides a higher efficiency and a greater overall length resulting in less screening. Particularly, on a small size cellular telephone, screening by the operator's head is a
20 problem with regard to operating range.

In WO-A1-97/42680 it is disclosed an antenna device for a portable radio communication device, where a radiating first element is substantially directly connected to the impedance
25 matching means.

WO-A1-98/07208 discloses an integrated matched antenna assembly, having a matching circuit including an inductor formed on a substrate. A capacitive element having two
30 conductors in spaced relation to each other is connected to the inductor by one of the conductors being arranged parallel to the inductor. This arrangement requires several conductive

layers and at least two substrates. Further, wires can be used for connecting components of the matching device.

JP-A-6152221 discloses an antenna for mobile radio equipment.

5 The antenna is connected to one terminal of a meandering transmission line whereof the other terminal is connected to ground, and a feed point is arranged on the transmission line. These arrangements are provided inside the telephone and require a feed line to the antenna feed portion, and discrete
10 capacitive components.

WO-A1-96/37007 discloses an antenna apparatus, wherein a radiator is connected to one end of a spiral conductor of which the other end is connected to a transceiver. A drawback
15 with this apparatus is that the spiral has one central and one peripheral connection. Further, a feed line is provided between a connecting portion of the spiral and the antenna.

Some general problems with matching devices or circuits are
20 that they are space demanding, complicated to assemble and complicated to mount. Generally, the arrangements of the connections also cause problems. This is especially apparent when the matching device is located inside a radiotelephone housing, includes discrete components, or is not or can not be
25 formed into a space optimising shape.

SUMMARY OF THE INVENTION

It is an object of the invention to obtain a matched antenna
30 device, which requires less space inside a telephone, and which can use the available space better.

It is also an object of the invention to obtain a matched antenna device, which can be produced at low cost in a simple manufacturing process.

- 5 Another object of the invention is to provide a matched antenna device, which is suitable for production in large quantities.

10 These and other objects are attained by a matched antenna device according to the appended claims 1-25.

By the arrangement of a matching means including a conductive pattern on a flexible substrate, it is obtained a matching means which can be attached to a radiotelephone and easily be
15 formed so as to adapt to the available space or surface.

By arranging a matched antenna device according to claim 1, it is achieved an antenna device which provides for simple connection.

20 By the arrangement of two antenna elements, an antenna device which is operable in multiple bands is obtained.

By arranging coupling means in end portions of the conductive pattern or matching pattern, it is obtained an efficient
25 matching means having simple connections.

By arranging coupling means to be located essentially on an envelope of the conductive pattern or matching pattern, it is
30 achieved an efficient matching means having simple connections.

By arranging the conductive pattern or matching pattern so that it includes a meander shaped portion, it is obtained an efficient matching means.

- 5 By arranging the conductive pattern or matching pattern on the same side of a substrate as a radiating conductive pattern, it is obtained an efficient matched antenna device having essentially no feed line between the matching means and the antenna element. It is also achieved an antenna device which
10 is simple to connect, and simple to manufacture at low cost.

By the arrangement of an extendable/retractable antenna element, it is achieved an efficient antenna device for operation in stand by mode and talk mode.

15

- By the arrangement of a conductive surface separated from the conductive pattern or matching pattern by a dielectric substrate, it is achieved an efficient matching means which easily can be adjusted for matching within desired frequency
20 ranges.

BRIEF DESCRIPTION OF THE DRAWINGS

- 25 Figure 1a shows a first embodiment of a matched antenna device according to the invention.

Figure 1b shows an equivalent circuit diagram of a matched antenna device, as shown in Figure 1a.

30

Figure 2a is a cross section taken at 2-2 in Figure 1a.

Figure 2b is an alternative cross section taken at 2-2 in Figure 1a.

Figure 3a shows a second embodiment of a matched antenna device according to the invention.

Figure 3b shows an equivalent circuit diagram of a matched antenna device, as shown in Figure 3a.

Figures 4a-d show alternative shapes of the conductive foil or surface in the matched antenna device according to the invention.

Figure 5 shows a matched antenna device according to the invention provided on a carrying structure.

Figure 6 is a section taken at 6-6 in Figure 5.

Figure 7 shows an embodiment of the invention, where an antenna rod is arranged to be slidable and at least partially encompassed by a matching means and an antenna element.

Figure 8 shows diagrammatically an arrangement for the feeding of the antenna rod in Figure 7.

Figure 9 shows a further embodiment of a matched antenna device according to the invention.

Figure 10 shows a further embodiment of the invention, where a antenna rod is arranged to be slidable and at least partially encompassed by an antenna element.

Figure 11 is a section of the embodiment shown in Figure 10, taken in a plane parallel with the paper in Figure 10.

Figure 12 shows an embodiment of a matched antenna device according to the invention which is to be applied on a support with overlap.

Figure 13 shows schematically how the matched antenna device according to the invention can be provided on a mobile telephone.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to Figure 1a, a first embodiment of the invention concerning a matched antenna device, generally denoted 1, is shown. The antenna device is particularly intended for a radio communication device, such as a mobile telephone. A flexible dielectric substrate 2 is provided, having on its first side 21, a conductive pattern or matching pattern 3. This pattern 3 is arranged on the substrate 2 in a meander shape, and exhibits a first coupling means 31 which is arranged to be connected to transceiver circuits of a radio communication device. At a side of the meandering pattern opposite to that of the first coupling means, the meandering pattern is provided with a second coupling means 32, which is connected to a feed portion 42 of a first 4 and a second 41 antenna element. Also the antenna elements 4 and 41 are conductive meander patterns arranged on the first side 21 of the substrate 2. Although two antenna elements are shown according to this embodiment, it is possible to have only one antenna element, or more than two antenna elements arranged on the substrate according to different variants of the invention. It is not necessary, but preferable that the antenna element(s)

4, 41 is (are) arranged on the same substrate as the conductive pattern 3. If arranged on different substrates, the coupling means 32 is connected to the feed portion 42 by a conductive or capacitive coupling means.

The conductive meandering pattern 3 exhibits capacitive and inductive characteristics, as shown in the equivalent circuit diagram shown in Figure 1b. It exhibits an impedance at the first coupling means 31 being 50 ohm, and provides matching between the antenna element(s) and the transceiver circuits of the radio communication device. Other impedances than 50 ohm can be selected, if desired.

By flexible substrate is meant a plastic substrate having no (glass) fibre reinforcement. Further, it should be possible to bend the flexible substrate around a cylindrical frame having a diameter less than one centimetre. Preferably, it should be possible to bend the flexible substrate to form edges or bend it with bending radii as small as one millimetre. A plastic film such as a flex-film is preferred as flexible substrate.

In Figure 2a a cross section of the antenna device of Figure 1a, taken at 2-2, is shown. Here it is seen that a conductive foil or surface 33 is arranged on the second side 22 of the flexible substrate, which also is indicated by broken lines in Figure 1a. The conductive surface 33 covers an area corresponding to the matching meander 3 (the conductive pattern), except for the curved portions and their vicinities indicated by 39. This surface serves as a ground plane, and is preferably connected to signal ground of the radio communication device by means of a conductive or capacitive coupling device. The conductive surface is not necessary for the function of the matching meander, but its presence is

preferred. However, if the conductive foil or surface 33 is omitted, some other capacitive components should be introduced e.g. stray capacitances coupled to signal ground. It is also a possible alternative to provide a carrying structure, to which the flexible substrate is attached, with a conductive foil or surface having preferably similar overlap with the conductive pattern 3, and function as the conductive foil or surface 33. The conductive foil or surface is preferably coupled to signal ground of the radio communication device conductively or capacitively.

Further, an adhesive 5 is arranged on the second side of the substrate 2. It can be an double sided tape or another type of adhesive, e.g. as is used for labels or stickers.

Alternatively, as shown in Figure 2b, the adhesive could be provided on the first side of the substrate, and covering the conductive pattern 3 and the antenna elements 4, 41.

For clarity the layers in Figures 2a and 2b are depicted to be thicker than they really are, in relation to other dimensions.

In Figure 1b an equivalent circuit diagram of the antenna device in Figure 1a is shown. The values of inductive and capacitive components depend on the shape of the conductive pattern 3 and the conductive foil or surface 33. Therefore, tuning is performed by shaping the conductive pattern 3 and the conductive foil or surface 33, in order to achieve the desired values. Those values also depend on the frequency, since the components are distributed. This dependence has the result that matching is achieved at various frequencies.

In Figure 3a a second embodiment of the invention is shown. It differs from the embodiment of Figure 1a essentially in that

the second coupling means 32 is a capacitive coupling device, and that the conductive surface has another coverage. The first coupling means 31 is preferably connected to the transceiver circuits of the radio communication device
5 conductively, e.g. by a contact device connected to a feed line, or directly to a PCB (printed circuit board) of the circuitry of the radio communication device. Alternatively a capacitive coupling can be employed. The second coupling means 32 is a interdigit capacitor. The conductive surface (33)
10 covers an area somewhat larger than an area corresponding to the conductive pattern 3, with the areas for the coupling means excluded. It could cover an area corresponding to an envelope of the conductive pattern 3, again, with the areas for the coupling means 34 excluded. The envelope is a curve
15 touching every curve of the meander pattern. Since the coupling means are included in the pattern they are included in the envelope.

In Figure 3b an equivalent circuit diagram of the antenna
20 device in Figure 3a is shown. It is similar to the diagram shown in Figure 1b, except for the capacitive coupling to the antenna element.

In order to achieve the desired characteristics for the
25 matching means including the conductive pattern or matching pattern 3, the conductive foil or surface 33, which also is included in the matching means, when present, can be formed in other shapes than those described above, whereof some possible shapes are shown in Figures 4a-d. In Figure 4a, the conductive
30 foil or surface 33 has the shape of a planar projection of an hourglass. In Figure 4b the shape is that of a rectangle with a central hole. In Figure 4c the shape can be described as a band exhibiting an elliptic extension at its central portion.

In Figure 4d the shape is like a planar projection of a funnel. Also other shapes or patterns are possible.

Referring to Figure 5, it is shown how a matched antenna device 1 is provided on a carrying structure or support 6. The support 6 is preferably made of an insulating material, and is elongated, preferably having essentially circular or elliptical cross section. It can also be described as frustum of a cone. In this embodiment the support is a frame of a type similar to those used to support antenna elements for some types of telephones using stub antennas, and which are mounted on a telephone chassi. The antenna device 1 is wound around the support 6, and fastened thereto by means of said adhesive 5. The size and shape of the antenna device 1 is such that it essentially covers the support 6, and it is intended to be applied in one turn around the support 6 without overlap. The support 6 is provided with a hole 61 through which the coupling means 31 can be introduced for further connection with a signal conductor or feed line 82. The antenna device is protected by a cover 62 made of an insulating material (depicted with broken lines). The assembled antenna device is mounted to a radio communication device by means of a fitting 7, preferably provided with a threaded portion 71, which is received by a corresponding part in or on the radio communication device. Alternatively, the antenna device can be attached by snap action devices. The fitting 7 or the snap action devices can be made of conductive or insulating material. The signal conductor or feed line 82 is connected to the circuitry of the radio communication device by direct contact or by means of a connection device.

Figure 6 shows a section taken at 6-6 in Figure 5. A conductive pin 8 provided with a head 81 is used for making

contact with the coupling means 31, and serves as signal conductor or feed line 82. The pin is locked with locking members 83, and a pressure is created between the head 81 and the bottom of the chamber in the support 6, so that the coupling means 31 is secured therebetween.

In figure 7 it is shown an embodiment of the invention, where an antenna rod 9 is arranged to be slideably movable, through the support 6, between an extended and a retracted position. In this case the fitting 7 is not filled with an insulating material so that the rod can slide therethrough. The fitting 7 is preferably made of a conducting material and the coupling means 31 is connected to the fitting, which is to be connected to the circuitry of the radio communication device.

The antenna rod 9 can be fed in different ways, whereof one is shown in Figure 8. The antenna rod includes a conductive rod provided with an insulating cover. Preferably a top portion, essentially with the same length as the extension of the antenna element 4 in a direction parallel with the antenna rod 9, of the antenna rod 9 is made of insulating material only. In Figure 8 it is shown that the antenna rod is coupled capacitively, with its conductive portion to the antenna element 4, preferably to the top portion thereof, when the rod antenna 9 is in its extended portion.

In the embodiment of the invention shown in Figure 9, the second coupling means 32 is coupled to the feed portion 42 of the antenna element or radiating pattern 4. This antenna element comprises a straight portion 43, a meandering portion 44 and a top capacitance 45, which includes a metallic strip 45. By arranging the straight portion, the radiating parts

will be more separated from the phone and the matching means, which can be advantageous.

In figure 10 it is shown a further embodiment of the invention, where an antenna rod 9 is arranged to be slideably movable, through the support 64, between an extended and a retracted position. In Figure 11, which is a cross sectional view of the device of Figure 10, it is shown that the antenna rod is slidably arranged in a channel 63, arranged in the support 64. A conductive pattern 3 and at least a conductive radiating pattern 4 are arranged on the support 64. Preferably a conductive foil or surface 33 is provided under the conductive pattern 3, as described in connection with the embodiments above. The connection of the conductive pattern 3 and the conductive radiating pattern 4 is arranged separated from the opening for the antenna rod 9. The connection pin 8 is connected with the first coupling means 31 in a similar way as described above, even if other ways are possible. The signal conductor or feed line 82 is surrounded by insulating material, but not necessarily a conductive fitting as described in previous embodiments. Instead a conductive part or attachment belonging to the telephone housing can form an outer conductor of a coaxial feed line.

In Figure 12 an alternative embodiment of the invention is shown. The substrate 2 has a width essentially twice that of the substrates 2 shown in Figures 1a or 3a. Here the substrate 2 is provided on its first side 21 with a conductive pattern or matching pattern 3, a first coupling means 31, a second coupling means 32, a feed portion 42, a first 4, and a second 41 antenna element, as described above. Those are provided on the left hand half of the substrate. On the first side 21 of the other half a conductive foil or surface 33 is arranged.

The substrate is further provided on its second side (back side) with an adhesive, as described above, in connection with the previous embodiments. Alternatively the adhesive can be provided on the first side, as described above. When applied on a carrying structure or support, the substrate is wound around the support with overlap, so that it will be applied with two turns. Thus the conductive pattern 3 will be located over or under the conductive foil or surface 33. The connections, the function, and the form of the conductive foil or surface 33 can be the same as described above.

Figure 13 shows schematically how the matched antenna device according to the invention can be provided on a mobile telephone. As seen, the signals to be transmitted T_x and the received R_x signals are fed to and from a diplexer, respectively. The signals from/to the diplexer are transmitted via a transmission line to/from the matching means M (corresponding the conductive pattern or matching pattern 3, and the conductive foil or surface 33, when present, as described above). As seen the transmission line T_L crosses the border between the telephone and the antenna device. The transmission line T_L preferably is a coaxial transmission line, but could be any kind of non-radiative transmission line. Such a transmission line could for example be a microstrip line, pair conductor or single conductor, having a specific impedance, preferably 50 ohm. A portion of the outer conductor of the transmission line T_L can belong to the antenna, e.g. be formed by a part of a fitting. Alternatively, this portion can be formed by a conductive part or an attachment belonging to the telephone housing, e.g. a screw threaded portion.

The transmission line can also be divided into two parts, one for the antenna device and one for the phone itself. The latter

includes the last track of the PCB (pattern of the PCB between diplexer and the antenna connector) and the antenna connector. The antenna connector is preferably located on the PCB.

- 5 In the embodiments described above, the conductive patterns 3 and the conductive radiating patterns 4, 41 may be formed by initially plating the surface of the flexible substrate 2 with a metallic layer, and then selectively etching away the layer to expose the flexible substrate 2 according to a pattern
- 10 applied in a photographic layer similar to that used for etching printed circuit boards. Alternatively the metallic material may be applied by selective deposition or by printing techniques.
- 15 Although the invention is described by means of the above examples, naturally, many variations are possible within the scope of the invention. For example the matched antenna device or parts thereof can be arranged inside a telephone, though only mounting outside has been described.

CLAIMS

1. A matched antenna device (1) for a radio communication device, comprising a matching means (3, 33) and a first antenna element (4),
5 c h a r a c t e r i s e d i n t h a t
- the matched antenna device further comprises a flexible dielectric substrate (2) having a first side (21) and a second side (22),
 - 10 - the matching means (3, 33) comprises a conductive pattern (3), having a first coupling means (31) and a second coupling means (32), and exhibiting inductive and capacitive characteristics, arranged on the first side (21) of the flexible substrate (2),
 - 15 - a signal ground conductive surface being capacitively coupled to the conductive pattern (3),
 - the first coupling means (21) is to be coupled to the circuitry of the radio communication device,
 - the first antenna element (4) having a first end and a second end, a feed portion (42) being arranged at the first end, and
 - 20 - the second coupling means (32) being coupled to the feed portion (42) of the first antenna element (4).
- 25 2. A matched antenna device according to claim 1, wherein
- the flexible substrate (2) is arranged on a carrying structure, and
 - the first coupling means (31) is connected to a signal conductor of a transmission line whereof at least a
 - 30 portion of a ground conductor is constituted of a conductive fastening means, for fastening the carrying structure to the radio communication device, said fastening means encompassing the signal conductor.

3. A matched antenna device according to claim 1 or 2, wherein
- the first coupling means (31) is connected to one end
of a transmission line, of which the other end is arranged to
5 be connected to transceiver circuits of the radio
communication device and exhibits an impedance matched to said
transceiver circuits.

4. A matched antenna device according to any of claims 1-3,
10 wherein

- each of the first coupling means (31) and the second
coupling means (32) are included in a respective end portion
of the conductive pattern (3).

5. A matched antenna device according to any of claims 1-4,
15 wherein

- each of the first coupling means (31) and the second
coupling means (32) are located essentially on an envelope of
the conductive pattern (3).

6. A matched antenna device according to any of claims 1-5,
20 wherein

- the conductive pattern (3) includes a meander shaped
portion.

7. A matched antenna device according to any of claims 1-6,
25 wherein

- the first coupling means (31) provides conductive
coupling.

8. A matched antenna device according to any of claims 1-7,
30 wherein

- the second coupling means (32) provides capacitive coupling.

9. A matched antenna device according to any of claims 1-7,
5 wherein

- the second coupling means (32) provides conductive coupling.

10. A matched antenna device according to any of claims 1-9,
10 wherein

- the first antenna element (4) includes a radiating conductive pattern (4) being arranged on the first side (21) of the flexible substrate (2).

15 11. A matched antenna device according to claim 10 further comprising a second antenna element (41), wherein

- the second antenna element (41) including a radiating conductive pattern (41) arranged on the first side (21) of the flexible substrate (2), and having a feed portion (42)

20 connected to the feed portion (42) of the first antenna element (4).

12. A matched antenna device according to any of claims 1-11 further comprising a third antenna element (9), wherein

25 - the third antenna element (9), being extendable/retractable, is arranged to be coupled to the circuitry of the radio communication device when in its extended position, and

- the flexible substrate (2) is arranged to at least
30 partially encompass the third antenna element (9) when in an extended position.

13. A matched antenna device according to claim 12, wherein

- the third antenna element (9) is coupled capacitively to the first antenna element (4).

14. A matched antenna device according to claim 12, wherein

5 - the third antenna element (9) is coupled capacitively to the second coupling means (32).

15. A matched antenna device according to any of claims 1-14, wherein

10 - at least a portion of the second side (22) of the flexible substrate (2) is provided with a conductive surface (33).

16. A matched antenna device according to any of claims 1-14, wherein

15 - at least a portion of the first side (21) of the flexible substrate (2), which portion is separated from the conductive pattern (3) is covered with a conductive surface (33), and
20 - said substrate (2) is to be applied to a carrying structure so that portions of the conductive surface (33) and the conductive pattern (3) overlap.

17. A matched antenna device according to claim 15 or 16, wherein

25 - the conductive surface (33) covers an area of the second side (22) of the flexible substrate (2) essentially corresponding to and overlapping the area of an envelope of the conductive pattern (3).

30

18. A matched antenna device according to claim 15 or 16, wherein

- the conductive surface (33) covers a region of the second side (22) of the flexible substrate (2) essentially included in a region corresponding to and overlapping the area of an envelope of the conductive pattern (3), and

5 - the conductive surface (33) has one of the shapes included in the group consisting of: a rectangle, a rectangle with a central hole, a planar projection of an hourglass, a planar projection of a funnel, and a band exhibiting an elliptic extension at its central portion.

10 19. A matched antenna device according to any of claims 15-18, wherein

- the conductive pattern (3) includes a meander shaped portion, and

15 - the conductive surface (33) covers an area of the second side of the flexible substrate essentially corresponding to and overlapping the area of the meander shaped portion excluding areas (39) surrounding and including curved portions of the meander shaped portion.

20 20. A matched antenna device according to any of claims 1-19, wherein

25 - an adhesive (5) is provided on one side (21, 22) of the flexible substrate (2), in order to facilitate the attachment of the flexible substrate to a carrying structure (6).

21. A matched antenna device according to claim 20, wherein

30 - the carrying structure (6) has an essentially cylindrical shape.

22. A matched antenna device according to any of claims 1-21, wherein

- the flexible substrate (2) is bent around a longitudinal axis so as to exhibit a curved shape in at least a plane perpendicular to the flexible substrate.

5 23. A matched antenna device according to any of claims 15-22, wherein

- the conductive surface (33) is arranged to be capacitively coupled to signal ground of the radio communication device.

10

24. A matched antenna device according to any of claims 15-22, wherein

- the conductive surface (33) is arranged to be conductively coupled to signal ground of the radio communication device.

15

25. A matched antenna device according to any of claims 1-24, wherein

- the flexible substrate is arranged on a carrying structure, and

20

- the carrying structure is arranged to be mounted to a housing of the radio communication device, so that at least a major part of the matched antenna device will be located outside the housing of the radio communication device.

25

26. A portable radio communication device, characterised in that it is provided with a matched antenna device (1) according to any of claims 1-25.

30

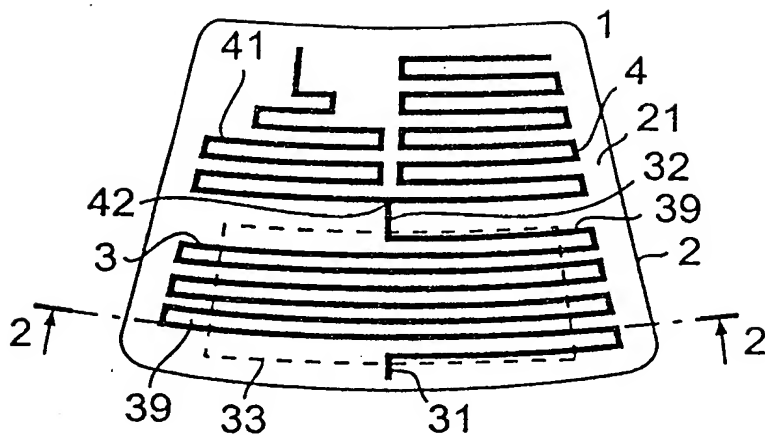


Figure 1a

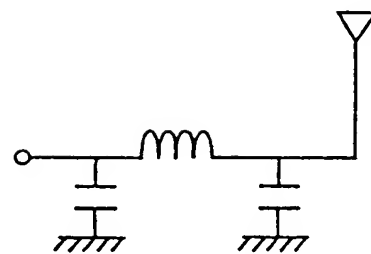


Figure 1b

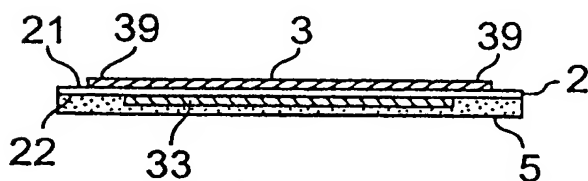


Figure 2a

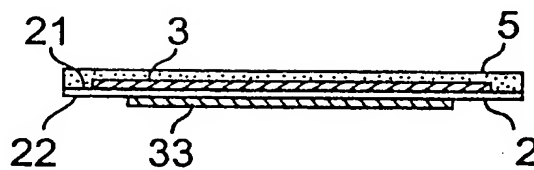


Figure 2b

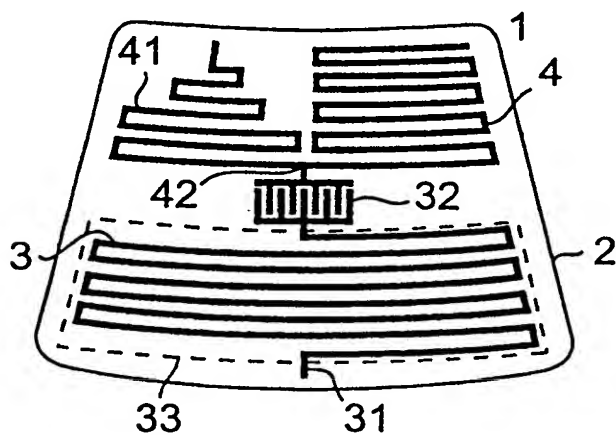


Figure 3a

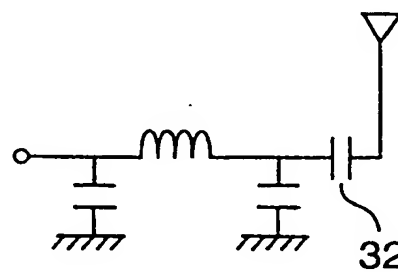


Figure 3b

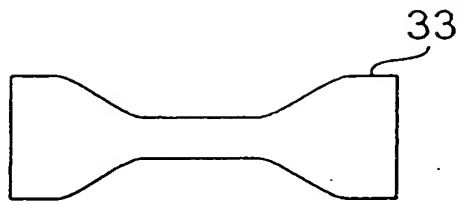


Figure 4a

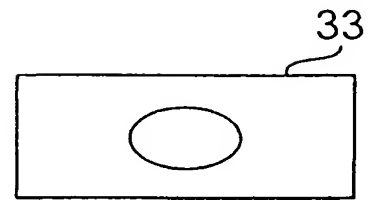


Figure 4b

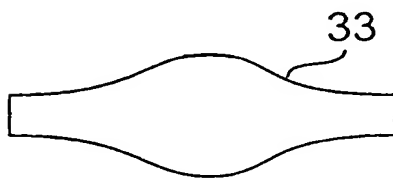


Figure 4c



Figure 4d

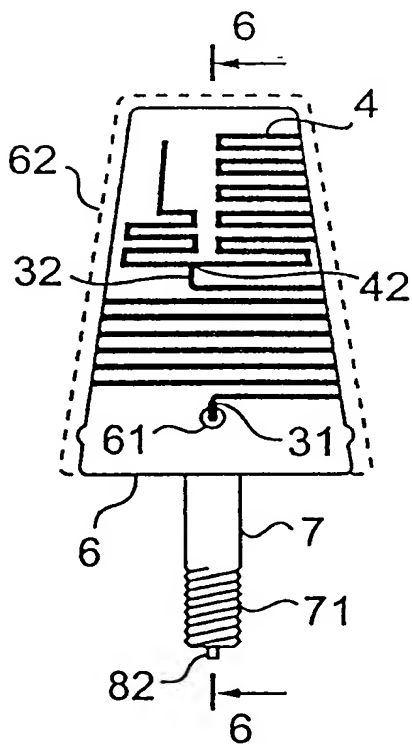


Figure 5

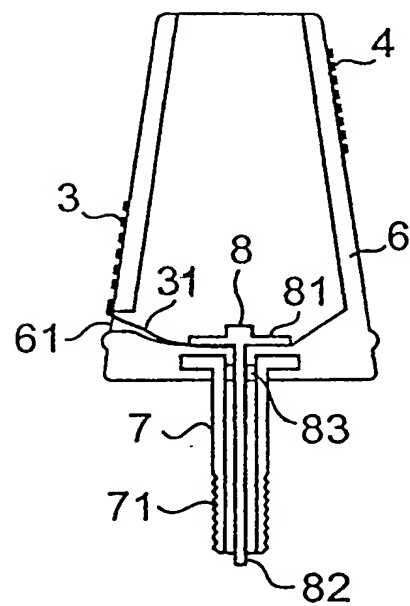


Figure 6

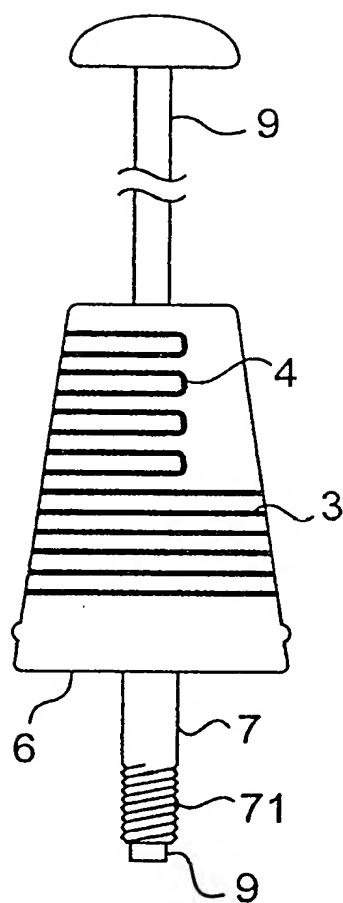


Figure 7

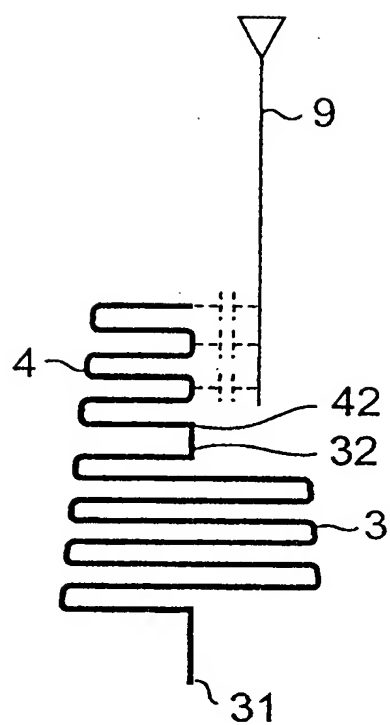


Figure 8

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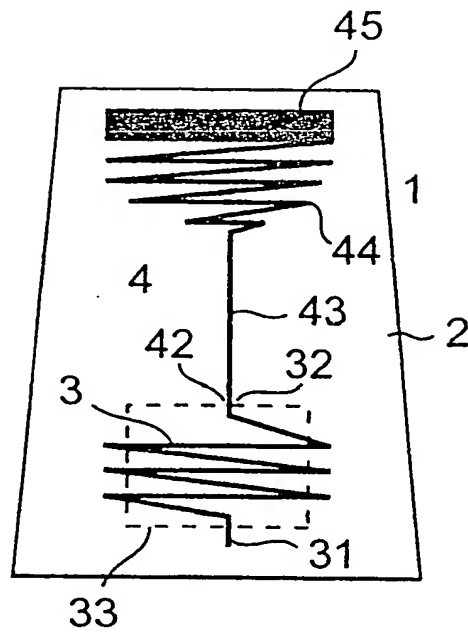


Figure 9

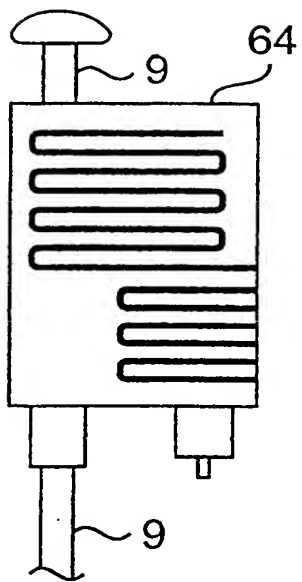


Figure 10

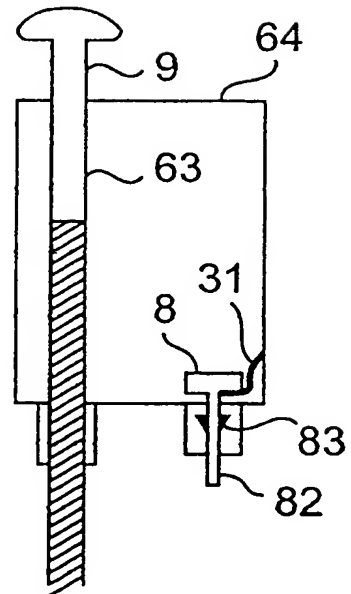


Figure 11

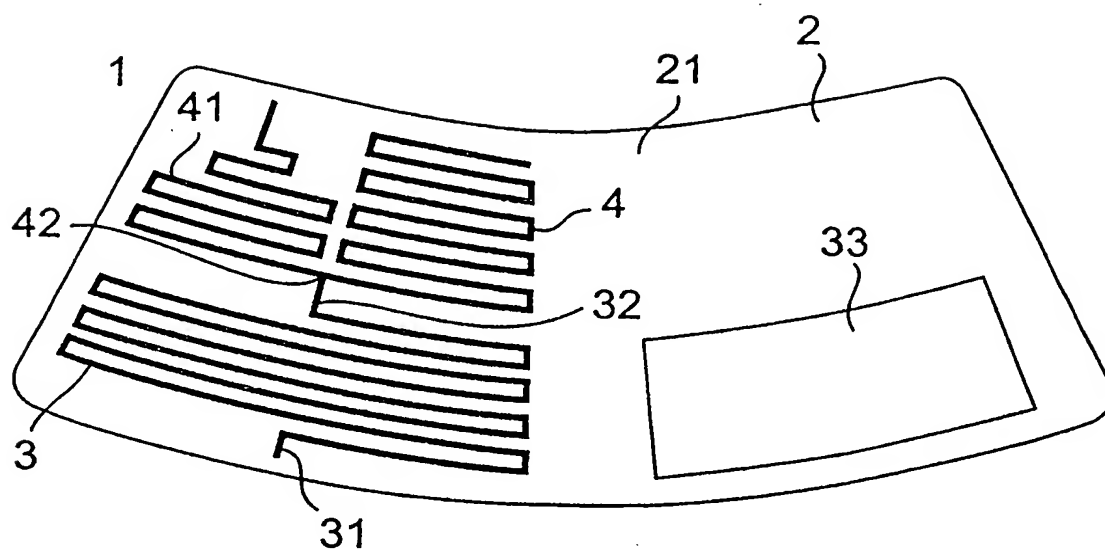


Figure 12

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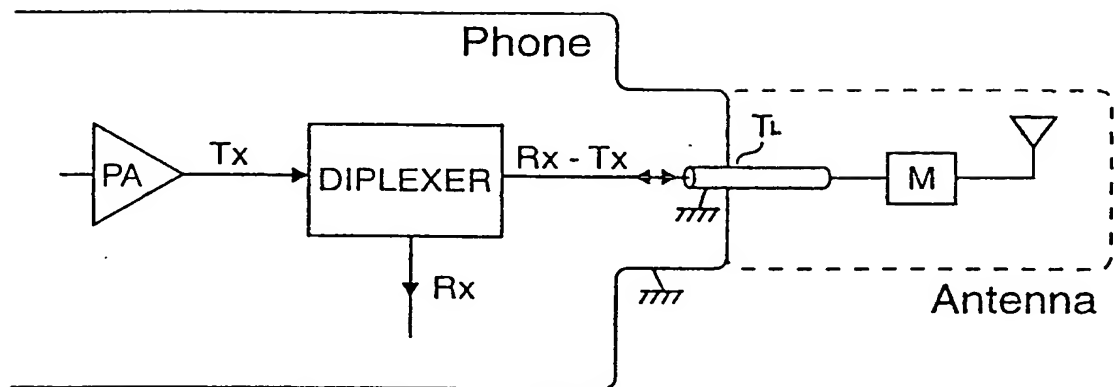


Figure 13

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 99/02070

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01Q 1/24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4328501 A (CHARLES M. DESANTIS ET AL), 4 May 1982 (04.05.82), figures 10,11,13 --	1-25
A	WO 9742680 A1 (ALLGON AB), 13 November 1997 (13.11.97), cited in the application --	1-26
A	JP 6152221 A (MATSUSHITA ELECTRIC IND CO LTD), 31 May 1994 (31.05.94), cited in the application --	1-26
A	WO 9637007 A1 (MOTECO AB), 21 November 1996 (21.11.96), cited in the application --	1-26

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search

22 March 2000

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 99/02070

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>WO 9807208 A1 (CENTURION INTERNATIONAL., INC.), 19 February 1998 (19.02.98), cited in the application</p> <p style="text-align: center;">-- -----</p>	1-26

INTERNATIONAL SEARCH REPORT

Information on patent family members

02/12/99

International application No.

PCT/SE 99/02070

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				CA	1152209 A	16/08/83
				US	4443803 A	17/04/84

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